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Study on Dynamic Machining Performance of Machine Tool Based on BP Network

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Abstract

It is analyzed on the relationship of the vibration and the machining performance of machine tool in this paper, and estimate the dynamics machining performance of machine tool on line based on BP (Back Propagation) network. Clustering is used to process data in order to reduce the number of data. Calculate speed of estimating system is increased by this method of data processing and satisfied the need of estimating on line. The 718 CNC is simulated with 25 groups of faulty state data and 25 groups of normal state data, and the simulation results show that the system can accurately estimate the dynamic machining performance of machine tool. The estimated method is very important to maintenance for machine tool.

Keywords: Machine tool; Dynamics; Machining performance; BP network; Estimate;

1. Introduction

Machine tool is the base of industry and all industry manufacture must depend on machine tool. And the precision and development of machine tool shows the development degree of the country. Hence it is important to increase machine tool precision and boost performance development of machine tool. Machining performance is one of the important performances of the machine tool because it affects

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directly the quality of parts manufactured by machine tool. Nowadays, literature is very less on study of machining performance change of machine tool home and abroad. Only Bin Li puts forward the monitoring system of machining performance of machine tool based on adaptive control. Judge the states of machining performance and fault types of machine tool. However the study is emphasized on relationship of all the control models but not the estimating of machining performance. In fact, machining performance of machine tool is changed with many factors such as machine tool's health state, work time, work condition and so on. In order to ensure machining quality of parts, it is required that machining performance is steady and reliable. Monitoring and estimating to machine tool can ensure machining performance of machine tool on time. The CNC (718 CNC) is analyzed in this paper.

There are many factors that affect machining performance of machine tool, such as distortion because of intensity and stiffness, distortion because of temperature changing, changes of system parameters, mechanical fault, working conditions and so on. And these factors will result in changes of dynamics of machine tool in the end. In other words, these factors will lead to vibration changing of the key parts such as spindle, lead screw and guide. Accordingly, estimate machining performance of machine tool by vibration signals.

BP network is adopted to estimate machining performance of machine tool in this paper. Find the mapping relationship between vibration and machining performance by BP network, then monitor and estimate machining performance by vibration.

2. Estimating model of machining performance

Dynamic BP network is adopted to be machining performance estimating model of machine tool. BP network is one of multilayer feed forward networks, and train network in back-propagation algorithm. Fig.1 shows three layers BP network which has multiple input and single output. $p_{i,j}$ is the weight of input layers and hidden layers(i input layer and j hidden layer), and w_i is the weight of hidden layer and output layer(i hidden layer and output layer). The activation functions of hidden layers are sigmoid functions showed in formula (1). u_i is the input signals of the i neuron in hidden layer, and v_i is the output signals of this neuron.

$$v_i = \frac{1}{1+\exp(-u_i)} \tag{1}$$

Weights can be adjusted which is the network has dynamic performance in order to estimate dynamic machining performance of machine tool on line.

3. Design of test

The tests are designed based on 718 CNC. Fig.2 shows the brief structure of 718 CNC and sensors installation locations. The rotation speed of lead screw is lower speed and vibration of lead screw is low frequency, strong directivity vibration. Hence two single-direct vibration sensors are installed on bearing block horizontally and vertically. The vibration of lead screw is measured by three-direct vibration sensor which is installed on nut seat of lead screw. Single-direct accelerator sensor (type INV9821) is adopted as the single-direct vibration sensor made in China Orient Institute of Noise & Vibration. Three-direct

accelerator sensor (type INV9832) is adopted as three-direct accelerator sensor made in China Orient Institute of Noise & Vibration. Vibration signals of lead screw are measured by these sensors.

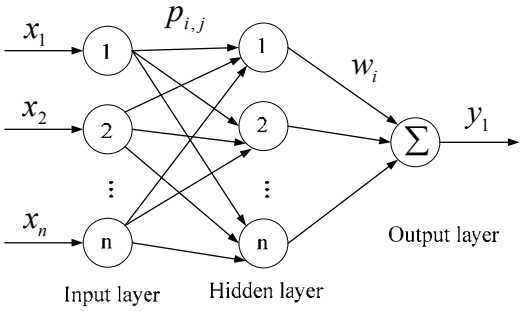


Fig. 1.BP network topology structure

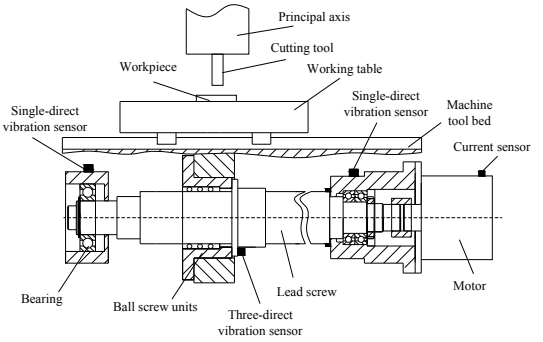


Fig.2 brief structure of 718 CNC and sensor installation locations

4. Algorithm design and data processing

There is disturbance in the vibration signal obtained from sensors so it is indispensable to clear up disturbance of vibration signals. To some key parts, such as lead screw, depart the low-frequency and high-frequency signals from vibration signals. The normal signals of lead screw are showed in Fig.3. Fig.4 shows the original faulty signals of lead screw. Fig.5 and Fig.6 show high-frequency part and low-frequency part of the vibration.

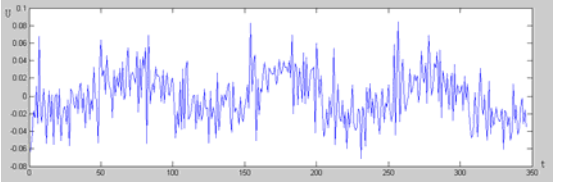


Fig.3 normal signals of lead screw

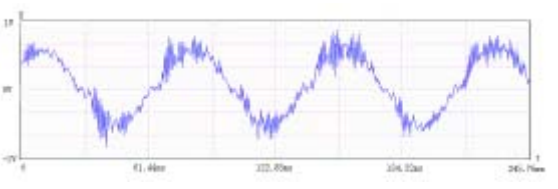
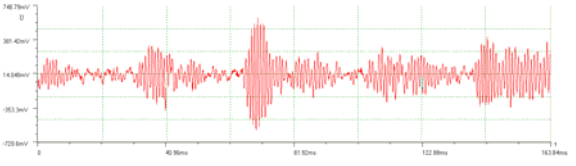


Fig.4 faulty signals of lead screw

In order to increase processing speed of estimating machining performance, reduce the number of data in the case that the system can meet requirements of precision. And clustering method is used to process vibration signals. That is segmenting vibration signals into some small parts. And calculate the mean of data in each small part to be the data of this part. For the lead screw of 718 CNC, the number of data is 65536. However, when set threshold to be 0.005V, the number will reduce to be 16381 when process the data with clustering. Hence calculating time will reduce a quarter.



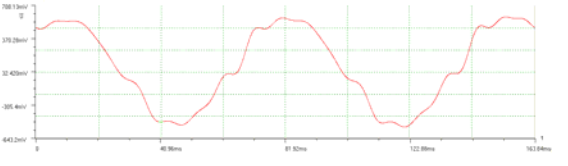


Fig.5 High-frequency part of faulty signals

Fig6. Low-frequency part of faulty signa

The principle of clustering is showed in Fig.7 and Fig.8, and the calculating process of clustering is showed in Fig.9.

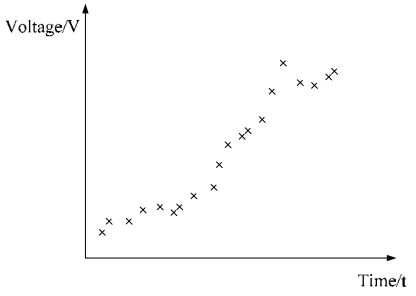


Fig.7 Original vibration signals

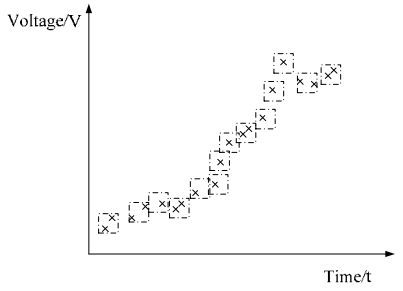


Fig.8 Clustering vibration signals

5. Result Analysis

Estimating the performance of lead screw to 718 CNC with dynamic BP network, and classify the results into two parts (normal state and faulty state). The dynamic machining performance is all right in the case of normal state and the dynamic machining performance can not meet the machining precision requirement. The results of simulation are showed in table 1. Test the estimating method with 25 groups of normal signals and 25 groups of faulty signals. The results of simulation show that the method can correctly classify normal state and faulty state.

Table 1 Values of states

Machine tool state	Results of simulation
Normal state	1
Faulty state	0

6. Conclusion

Dynamic machining performance is researched in this paper. Then take lead screw of 718 CNC machine as test part. Design the test scheme and positions of sensors reasonably. Then process vibration signals with cluster method to reduce the number of data in order to increase the processing velocity. Estimate dynamic machining performance of machine tool with dynamic BP network. Test the estimating system with 25 groups of normal signals and 25 groups of faulty signals. And the simulation results show that the system can correctly classify normal signals and faulty signals.

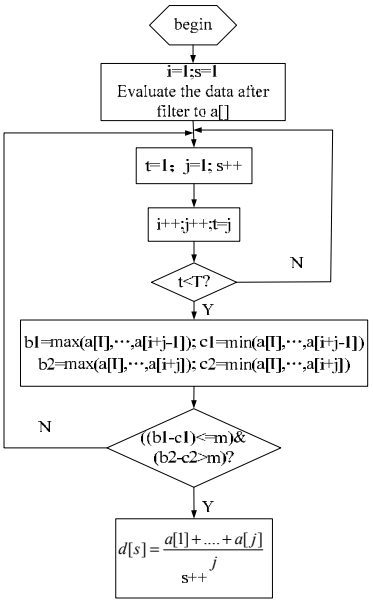


Fig.9 Cluster flow chart

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